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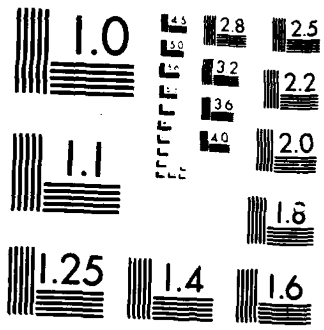

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ENVIROSAT–2000 Report

Analysis of Past Funding for NOAA'S Satellite Programs

January 1985

ENVIROSAT-2000

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

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D. Namian, D. Weiss, A. Schwalb

Washington, D.C.
January 1985

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
Anthony J. Calio, Deputy Administrator

National Environmental Satellite, Data, and Information Service
John H. McElroy, Assistant Administrator

ANALYSIS OF PAST FUNDING FOR NOAA'S ENVIRONMENTAL SATELLITE PROGRAM (FY 1971 - FY 1985)

ABSTRACT

This report provides an analysis of Federal funding for the operational civil environmental satellite program during the fiscal years 1971 through 1985. Both the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) budgets are examined. Four reasons for recent NOAA satellite funding increases are discussed: (1) responsibilities shifted from NASA to NOAA; (2) NASA decisions that required NOAA system changes; (3) an expanded NOAA satellite mission; and (4) exceptional inflation in the aerospace industry. The analysis reveals a decrease in the real cost of the service component of the satellite program over the years. It also concludes that there has been no growth in the cost of those program components traditionally funded by NOAA, and that only a few percent increase in cost has been experienced in the sum of program funding provided by both NOAA and NASA over the 15-year period.

INTRODUCTION

This analysis covers the years from 1971 through 1985, a period of maturation for NOAA satellite systems. Developments relied heavily on a highly successful sharing of responsibilities between NOAA and the nation's lead civil agency for space technology, NASA. In 1972, NOAA 2 became the first operational polar satellite to be equipped exclusively with scanning radiometers, ending a dozen years of reliance on TV cameras for cloud imaging. These calibrated sensors improved the quality of day and night cloud imagery, made it possible to measure sea surface and cloud top temperatures, and added new skills to quantitative applications like atmospheric temperature profiling.

The Geostationary Operational Environmental Satellite (GOES) system was initiated in 1974, utilizing the two protoflight models of NASA's Synchronous Meteorological Satellites (SMS) for early data. GOES 1, the first of NOAA's geosynchronous series, was deployed in 1975. With the GOES system, the capability was obtained for continuously monitoring hazardous weather events.

The modern NOAA polar orbiting spacecraft, the Television and Infrared Observation Satellite (TIROS-N), was introduced in 1978. In 1983, the Advanced TIROS-N (ATN) model became operational, meeting new requirements for sensor accommodation and power. Among other payloads that the ATN made possible is the new satellite-aided search and rescue (SARSAT) equipment used to detect and locate emergency transmissions from downed aircraft and ships in distress.

Planning and a conservative approach toward new space technology allowed these many satellite improvements to be introduced into the operational system without a break in mission accomplishment. Satellite losses and shortened service lifetimes have been experienced, but national needs for environmental data acquisition, processing, and distribution have been met throughout the period.

The funding needed to meet the mission goals has increased considerably since the early 1970's. The budget for NOAA's satellites, launching, and services is $258 million in FY 1985. This analysis examines the reasons for budgetary changes over the past 15 years. Four categories of increase stand out and are discussed:

- A shift of responsibilities from NASA to NOAA
- NASA decisions that required NOAA system changes
- An expanded NOAA mission with consequent systems growth
- Inflation, especially the higher rate of the aerospace industry

Two principal factors that will bear on the future cost of NOAA's satellite programs emerged from this analysis as candidates for further consideration. These factors are technical improvements that lead to increases in satellite lifetimes and procurement strategies that achieve the economies of quantity satellite purchases while smoothing the year-to-year budget profile. Both involve considerations of technology, national programs, Federal policy, and international cooperation. These considerations will be addressed in subsequent ENVIROSAT-2000 component studies dealing with the forecasted requirements and technical solutions for the balance of this century.

CHANGING RESPONSIBILITIES BETWEEN NASA AND NOAA

Over the later years of this analysis period, NASA experienced budget constraints and changing mission emphasis that resulted in a drawback from most of its commitments to develop and improve the operational satellite systems of NOAA. This drawback was consistent with the Administration's general policy that the benefitting user agencies should carry the full funding responsibilities to conduct their missions. These earlier commitments are included in the current formal basic agreement for satellite activities existing between NASA and the Department of Commerce (DOC). The agreement states:

> Recognizing the broad responsibilities of NASA under the Space Act for continuing a research and development program for the development of space technology and satellite systems for (1) application to operational systems and (2) research activity in the environmental sciences...

and

> The DOC by law has the basic responsibility for the establishment and operation of its operational satellite systems, which include obtaining funds.

and

> NASA by law has the basic responsibility for the development of new and advanced technology, and operational prototype spacecraft as required, in support of operational satellite systems, which includes obtaining necessary funds.

and

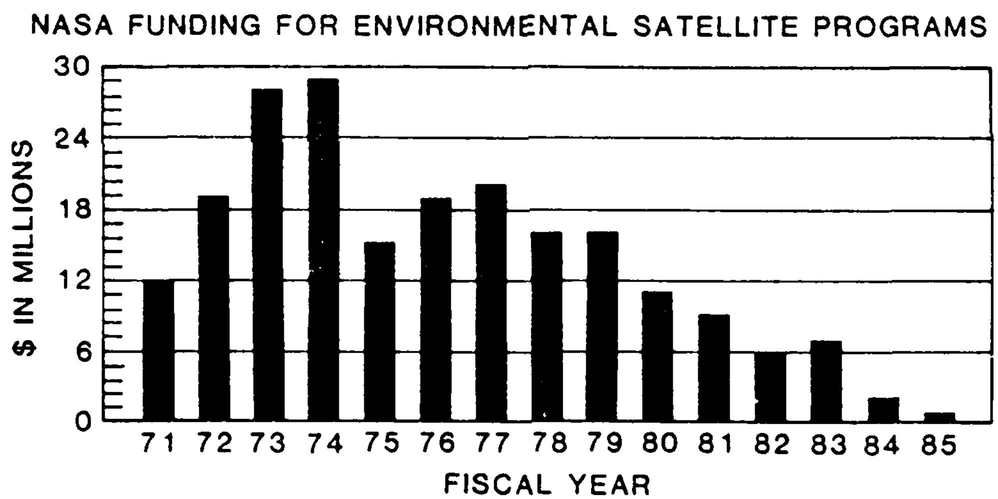
> NASA will fund for and manage the supporting technology effort for relevant operational satellite development programs.

NOAA's satellite budgets, personnel levels, distribution of expertise, and organizational structure were cast in the 1960's and 1970's to reflect the availability of NASA support to NOAA's satellite mission that this agreement conveyed. Today's realities, becoming evident over the last three or four years, have caused renegotiation of the basic agreement to be initiated and have shifted to NOAA the responsibilities for funding satellite developments necessary to meet operational requirements. The general agreement that NASA would fund for the development of new instruments and satellites to meet the operational requirements of NOAA no longer holds. Also, the NASA Operational Satellite Improvement Program (OSIP) has been terminated. The last major development under OSIP was the protoflight model of the Solar Backscatter Ultra-Violet (SBUV) instrument, important to atmospheric ozone and climate measurements. This instrument is now on-orbit aboard NOAA 9.

When it is necessary to change and improve NOAA capabilities, as in the case of developing the Advanced Microwave Sounder Unit (AMSU), NOAA must now fund the development. The AMSU example illustrates a common situation in space technology where a necessary change (here, the predecessor instruments are no longer manufactured) also offers the opportunity for improving services.

The magnitude of the NASA contribution to NOAA's operational systems over the past 15 years can be seen from the results that were achieved. These achievements include the design, building, and launch of the TIROS-N satellite and the funding of modifications that were necessary to produce the Advanced TIROS-N spacecraft. NASA also funded the SMS-A and B geostationary spacecraft and launched them in the proof-of-concept effort that led to NOAA's GOES system. NASA developed and demonstrated the operational satellite instruments during this period. NASA also developed and flew numerous experimental instruments, many of them forerunners to operational instruments, on Nimbus satellites. These were important contributions made by NASA. This analysis was conducted, in part, to clarify NOAA's budget trends with respect to NASA's recent budget decisions, which have altered NASA's ability to continue the previous level of effort.

The following graph shows the funding levels previously provided by NASA in support of NOAA's operational satellite programs. The cumulative contribution by NASA was $208.4 million. Appendix I shows a breakdown of this funding by fiscal year.



As a result of the discontinuance of NASA's direct support, NOAA has had to include funding for developmental efforts and satellite improvements in its budget, which has added $39 million to the FY 1984 and FY 1985 NOAA budgets. Appendix II lists development efforts carried in NOAA's budget that would have been funded by NASA if the provisions of the NASA/DOC basic agreement were in force.

NOAA SYSTEM CHANGES RESULTING FROM NASA DECISIONS

NOAA budgets had been set over the years at levels that reflected the continuation of NASA-provided satellite support systems. Several of these support systems have been terminated by NASA, leaving NOAA with the task of finding and funding alternate ways to meet mission obligations. The two NASA decisions with the largest impact were (1) to end all of NASA's expendable launch vehicle (ELV) activities and (2) to reduce greatly NASA's worldwide tracking and data acquisition ground network. The first change came about when NASA made the Space Transportation System (Shuttle) its exclusive launch system, once the delays in proving the Shuttle concept were overcome. The second modification resulted when the initial Tracking and Data Relay Satellite System (TDRSS) implementation was achieved, and NASA accepted TDRSS for its data acquisition needs, in place of the ground system. Both of these actions took place in time frames that are short compared with the 10 or more years spanned by each NOAA operational satellite series.

To accommodate the NASA Space Shuttle decision, in the case of the geostationary system, NOAA must develop a Shuttle-compatible GOES-Next spacecraft and accept higher launch costs for the remaining two GOES satellites of the present series. NOAA will fund the maintenance and readiness of the Delta launch facility at the Kennedy Space Flight Center, as its sole user, until at least mid-1986. In the polar system case, where launches take place at Vandenberg Air Force Base, California, NOAA will face the higher launch costs associated with being the only civilian agency sharing ELV facilities costs with the DOD and maintaining a launch readiness capability on its own behalf.

NOAA's environmental satellites are not equipped, nor would they have priority, to communicate efficiently through TDRSS. A principal data acquisition and command and control requirement for NOAA's polar environmental satellites is that they communicate through the Command and Data Acquisition (CDA) station at Gilmore Creek, Alaska. For almost 20 years, until October 1984, NOAA shared this ground facility with NASA. The NASA decision to end its ground station dependence resulted in NOAA assuming sole responsibility for operating and funding this station starting in FY 1985, at an increased cost of approximately $3.7 million annually.

The total additional cost to NOAA resulting from NASA decisions has been approximately $25.2 million through FY 1985. Appendix III lists these cost increases by program.

NOAA MISSION GROWTH AND SYSTEM IMPROVEMENTS

During the period of this analysis, 1971-85, NOAA's environmental satellites were increasingly recognized for both reliability and utility. Over this time period, they replaced and/or augmented other observational systems; in many instances, as in polar or ocean regions, satellites are the only feasible observation platforms. More importantly, the environmental and other service agencies have come to depend on satellite data as the basis for their routine operations and for their special requirements. With this growth in use and user expectations has come an accretion of NOAA satellite mission requirements. In parallel, science, technology, and the necessity for system changes have produced a steady flow of systems improvements that tend to add new demands for satellite data.

Examples of this cycle of mission growth and system improvements are seen in numerical weather prediction, severe storm forecasting, global indexing of vegetation, and the search and rescue capability. The early atmospheric Vertical Temperature Profile Radiometers (VTPR) that came into operational use in 1972 led to the development of numerical weather analysis that took advantage of their data. Instrument improvements were called for and provided with the result that, today, global numerical weather prediction depends on this input for maintaining the accuracy of its products. Severe storm forecasting in the United States took quantum leaps when sequential observations from geostationary altitude became available in 1974. Today, these observations are essential elements in dozens of severe weather, flash flood, and other programs for warning of threats to life and property.

The use of environmental satellite data has also extended to nontraditional applications. A significant new use for data received from the polar-orbiting Advanced Very High Resolution Radiometer (AVHRR) sensor is the monitoring of vegetative greening around the world; United States agencies and others use this technique on a daily basis for estimating crop production, crop disease, locust movements, drought, and other renewable resource conditions. In the case of the search and rescue program, NOAA's satellites offered suitable vehicles and orbits, and NOAA's ground systems offered the appropriate capabilities to accomplish this humanitarian task.

Although balanced in the national sense by gains in safety, better environmental advice, more accurate information, and elimination of other data collecting systems, this mission growth is reflected in NOAA's satellite budget as increased cost.

Another factor contributing to the growth in the early part of the period was the decision to join with the DOD to develop a common spacecraft for the polar-orbiting missions--the TIROS-N design. Prior to that time, NOAA spacecraft flew at a higher orbit, which allowed global coverage with a single spacecraft with redundant instruments. The new spacecraft could not fly in as high an orbit or carry two complements of instruments. Thus, two of the less expensive spacecraft were needed to provide the global coverage and the backup for catastrophic failure originally provided by the dual instruments. Newly designed instruments and spacecraft made an impact on the budget starting in FY 1975, when NOAA contracted for the first seven spacecraft of the TIROS-N design, NOAA A through G.

The following table provides a chronology of major satellite improvements:

NOAA Satellite Capabilities Introduced Between 1971 and 1985

Year	Satellite	New Capabilities	Remarks
1972	ITOS	Scanning Radiometer Vertical Temperature Profile Radiometer Very High Resolution Radiometer	All sensors were radiometers.
1974	GOES A	Visible and Infrared Spin Scan Radiometer (VISSR) Space Environment Monitor Data Collection System	SMS A and B were NASA protoflights.
1978	TIROS-N NOAA A-D	Advanced Very High Resolution Radiometer TIROS Operational Vertical Sounder Space Environment Monitor Data Collection System (ARGOS)	TIROS-N was NASA protoflight mission.
1980	GOES D-H	VISSR Atmospheric Sounder (VAS)	Allowed atmospheric sounding from geostationary orbit. VAS for GOES D was NASA funded.
1983	Advanced TIROS-N (ATN) NOAA E-J	Satellite-Aided Search and Rescue System (SARSAT) Solar Backscatter Ultra-Violet (SBUV) Instrument Earth Radiation Budget Experiment (ERBE)	These are new NASA-funded capabilities.

AEROSPACE INDUSTRY INFLATION RATE

The period of this analysis corresponds with a period of extraordinarily high inflation for the nation. The impact of inflation on NOAA's satellite programs has been aggravated by the fact that the inflation rate for the aerospace industry has been even higher than that for the general Consumer Price Index (CPI). The cumulative rate for the industry has been 325 percent, contrasted with 270 percent for the CPI. NOAA's contracts with the aerospace industry have reflected this situation throughout the period. The following table compares the CPI to the aerospace industry inflation rate.

Annual Inflation Rates

Fiscal Year	Consumer Price Inflation Rate (%)	Consumer Price Index	Aerospace Inflation Rate (%) [1]	Aerospace Index
1971	4.00	122.2	4.00	122.2
1972	3.27	126.2	3.27	126.2
1973	7.37	135.5	5.32	132.9
1974	11.96	151.7	9.90	146.1
1975	7.84	163.6	10.11	160.9
1976	5.50	172.6	8.35	174.3
1977	6.60	184.0	10.02	191.8
1978	8.32	199.3	7.89	206.9
1979	12.09	223.4	12.65	233.1
1980	12.67	251.7	14.30	266.4
1981	10.97	279.3	13.58	302.6
1982	5.01	293.3	10.91	335.6
1983	2.90	301.8	8.14	362.9
1984	4.50 [2]	315.3	4.50	379.2
1985	4.70 [2]	330.1	4.70	397.0

[1] These rates were derived from the following sources:

1979 to 1983 - GAO report B-213672 to Senator Brooks on compensation by 12 aerospace contractors.
1973 to 1978 - BLS "Production-Worker Average Hourly Earnings" for specific industry code 3761--"Guided Missiles and Space Vehicles."
1971 to 1972
and
1984 to 1985 - CPI figures used for years when other data were unavailable.

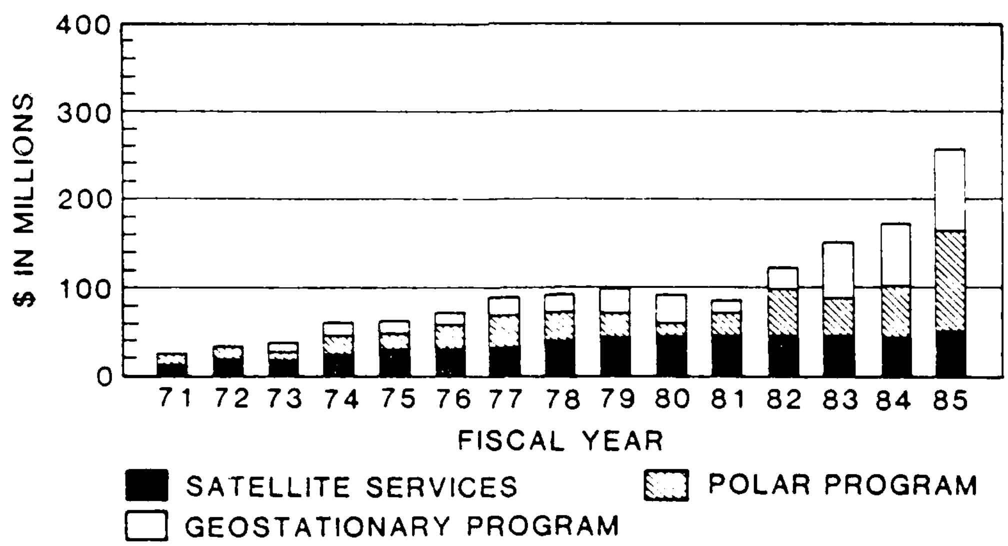
[2] CPI figures were not available; rates were derived from "key economic figures" projected in the President's FY 1985 budget.

SUMMARY

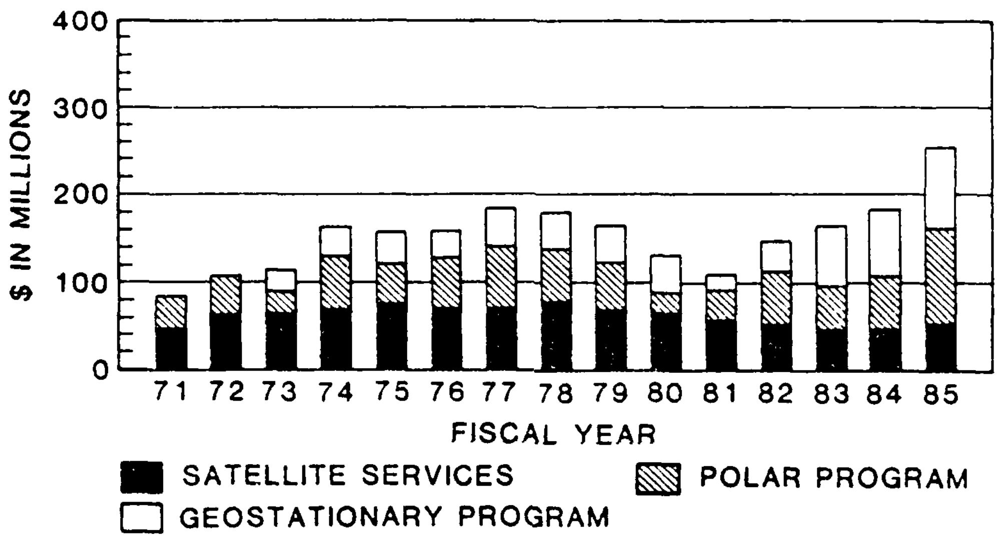
This analysis has identified and quantified the major factors that have influenced NOAA satellite program costs since 1971. The services portion of the budget has remained relatively constant, even though there has been a dramatic increase in product quantity, quality, diversity, and reliability. The annual cost for all services is approximately $55 million in FY 1985. This figure includes the total cost for operation of ground stations at Fairbanks, Alaska, and Wallops Island, Virginia; operation of the Satellite Operations Control Center at Suitland, Maryland; all research, development, and system planning activities; and the processing and distribution of the satellite data and products derived from the polar-orbiting and geostationary systems.

The increased cost for satellites and launches has come about because of inflation, interagency responsibility transfers, reactions to decisions made elsewhere, system improvements made in response to user needs, advances in technology, and increased mission responsibilities such as ozone monitoring and the search and rescue program. The following two graphs show NOAA funding for meteorological satellite programs--polar, geostationary, and services--first in "real year" dollars and then in constant dollars adjusted to FY 1985 values.

NOAA FUNDING BY PROGRAM IN REAL YEAR $

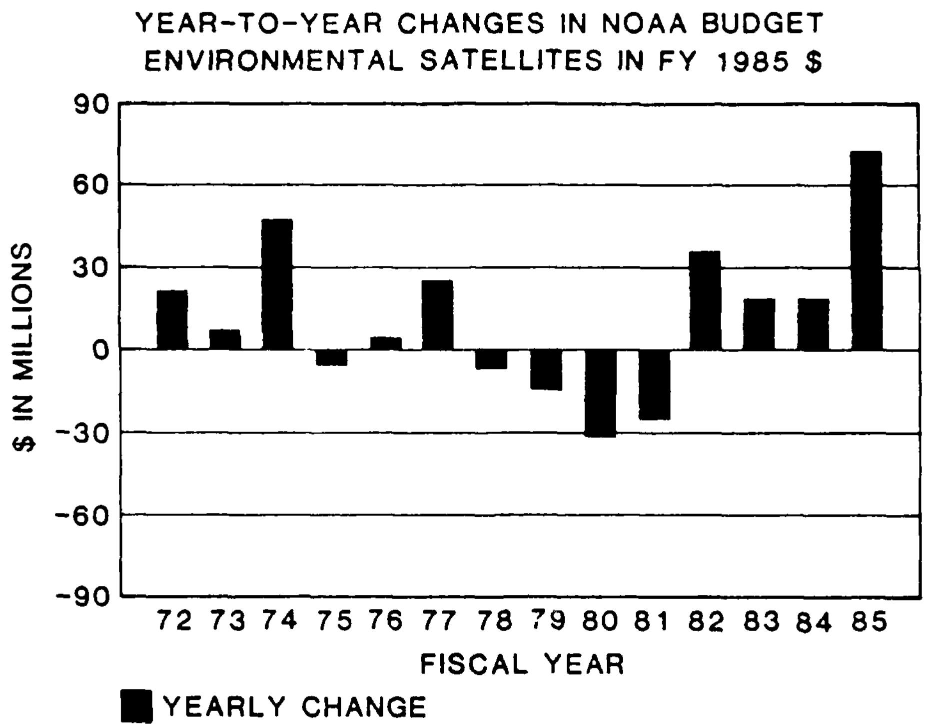


NOAA FUNDING BY PROGRAM IN FY 1985 $

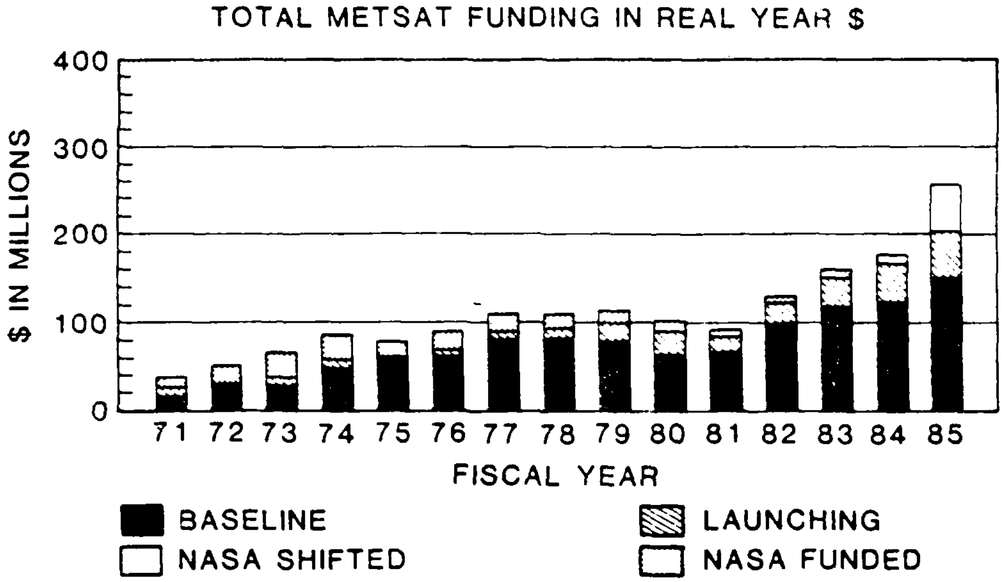


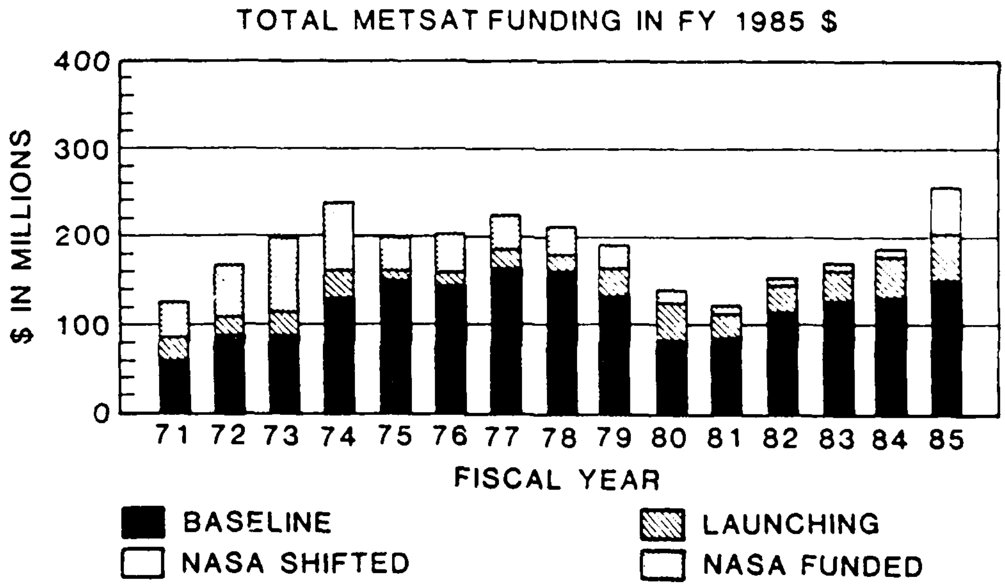
The preceding graph indicates the cyclical nature of satellite procurements, which require higher funding levels during the early years of a satellite series to obtain parts and sensors for all the satellites included in the series. This is particularly visible in FY 1985, a year in which NOAA will have five polar-orbiting and two geostationary satellites in production, plus a scheduled launch (NOAA G). In addition, contracts will be awarded to start the GOES-Next and the follow-on polar-orbiting program.

The FY 1985 surge in cost would have been avoided if additional satellites had been included with the GOES G and H procurement (started with a long lead parts agreement in September 1981) or with the NOAA H, I, and J spacecraft procurement (begun in August 1983). Had there been more satellites included with either of these programs, costs could have been more evenly spread from FY 1981 forward, eliminating the need to start replacement procurements of both programs in FY 1985. The following graph illustrates the year-to-year fluctuations experienced within the NOAA environmental satellite budget.



The final two graphs show the total cost history of these satellite programs--NOAA funding plus NASA funding--in "real year" and constant FY 1985 dollars. The latter graph demonstrates that there has been no growth trend in the satellite programs when the development funds previously provided by NASA are included.





Three conclusions can be drawn from the analysis. First, there has been a general decrease in the real cost of satellite services (i.e., the analysis of the data and the provision of products) over the last 15 years. Second, there has been no real growth in the cost of the part of the overall program traditionally funded by NOAA. Finally, total program expenditures, including both the NOAA and the NASA funded parts, have grown only a few percent over the 15 years of this analysis. Even with this limited growth in funding, the services provided by the satellites have improved substantially.

BREAKDOWN OF NASA FUNDING FOR ENVIRONMENTAL SATELLITE PROGRAMS
REAL YEAR $
(in thousands)

Fiscal Year	OSIP	TIROS-N	SMS A&B	ERBE[1]	SAR	Total
1971	3,195		8,774			11,969
1972	2,124		16,900			19,024
1973	1,611	4,000	21,900			27,511
1974	2,413	8,337	18,346			29,096
1975	3,468	7,254	4,760			15,482
1976	7,257	11,291				18,548
1977	4,900	14,678				19,578
1978	5,636	5,882			4,658	16,176
1979	6,080	1,200		2,960	5,955	16,145
1980	7,172			2,200	1,371	10,743
1981	6,929			320	1,453	8,702
1982	5,727			81	391	6,199
1983	5,950			586	275	6,811
1984	600			1,100	0	1,700
1985	0			465	300	765
Total	63,012	52,642	70,680	7,712	14,403	208,449

1 NASA Program--TIROS spacecraft mods only.

NOAA BUDGETED DEVELOPMENT COSTS PREVIOUSLY FUNDED BY NASA/OSIP
REAL YEAR $
(in thousands)

	Fiscal Years						
	1983	1984	1985	1986	1987	1988	1989
GOES I							
Spacecraft		5,000	25,000	40,000	30,000	20,000	
Launch				4,000	10,000	20,000	6,000
NOAA K,L,M							
Spacecraft Mods for:							
AMSU/AVHRR			1,000	4,000	5,000		
ELV			1,000	2,000	2,000	3,000	2,000
AMSU Protoflight			5,000	7,000	7,000	6,000	5,000
AVHRR Mods				500	500		
Near Noon Polar Orbit		1,000	1,000				
Total	0	6,000	33,000	57,500	54,500	49,000	13,000

NOAA BUDGETED ITEMS RESULTING FROM NASA DECISIONS
REAL YEAR $
(in thousands)

	Fiscal Years							
	1983	1984	1985	1986	1987	1988	1989	1990
Conversion to TDRSS:								
Gilmore CDA Station			4,300	3,700*	3,700	3,700	3,700	3,700
Changes to NASA Network and Shuttle Communications	3,700	1,300	1,500	2,500	200			
Space Transportation System:								
Delta Sole User Costs			14,000	21,000				
Atlas Sole User Costs							20,000	20,000
NASA WTR Launch Support			375*	375	375	375	375	375
NASA Technical Management:								
Contract Support				1,500*	1,500	1,500	1,500	1,500
OSIP Replacement:								
Next-Step					1,000	3,500*	3,500	3,500
Total	3,700	1,300	20,175	29,075	6,775	9,075	29,075	29,075

*Recurring

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